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THE HISTORICAL POINT OF VIEW IN THE TEACHING OF SCIENCE[1]

THE teachers of Missouri should take special interest in the history of science at the present time in view of the fact that the American Association for the Advancement of Science is expected to meet soon in this state and the question of forming a special section of this association for the purpose of considering topics in the history of science is to be raised during this meeting. Teachers of mathematics have an additional reason for taking an unusually keen interest in this subject just now in view of the appearance during the past summer of two very important books on the history of their subject. One of these is entitled "History of the Theory of Numbers" and was prepared by Professor L. E. Dickson, of the University of Chicago, while the other bears the more general title "A History of Mathematics" and was prepared by Professor Florian Cajori, of the University of California, who holds the unique position of a regular professorship of the history of mathematics in a university. The former book is the first volume of the most complete history of number theory ever written and marks an epoch in American mathematical literature, while the latter is technically only a "revised and enlarged edition" of a book which appeared a quarter of a century ago under the same title, but the changes are so extensive that it too may be regarded as practically a new work.

The history of science should also be of peculiar interest to all educated people at the present time in view of the fact that this history is now being made very rapidly. The important rôle played by science in the recent world war can never be forgotten, especially since it points to a largely increased impor-

[1] Read before the Missouri State Teachers Association, November 7, 1919.

tance of science in a future great war in case there will be another. Perhaps the immediate development of applied sciences will be retarded by the feeling of security which a League of Nations may foster but pure science, which constitutes the foundation of applied science, is in need of calmer times for its most vigorous and systematic development. While war exhibits forcibly the need of science, times of peace create the atmosphere for scientific growth from the bottom, and the great rôle which science played in the recent war was doubtless largely due to the long period of comparative peace which preceded it.

One of the most striking events in the history of science has been the recent termination of former international scientific organizations and the steps towards the formation of new ones with a greatly increased amount of machinery. The whirl of organization machinery like the thunder of the cannon may serve to exhibit needs of science but it can scarcely be expected to create an atmosphere suited for the best scientific growth. If the scientific organizations are to become as complex as our American university organizations, so that those who secure the most prominent positions are administrative experts instead of eminent representatives of scholarship and research, there is good ground for misgivings at the present time.

A possible portent of great significance not only in the history of science but also in the history of education in general is the disturbed money condition which enables one to secure at present foreign books at an unusually low price. I recently paid a bill for some French books which were contained in a parcel post shipment made by a German firm shortly before we entered the war and were siezed in transit by the British government. I had to pay less than one fifth of the pre-war price for these books as a result of the small present relative value of the German mark.

If somewhat similar conditions prevail for a considerable time it seems likely that America will secure an unusually large amount of the literature now stored in Germany. As a result thereof our scholars may soon enjoy the best library facilities in the world and with this should come greater initiative especially along historical lines. Europeans have often made fun of our magnificent library buildings containing a comparatively small number of books. It is to be hoped that this number will soon be greatly increased as books are the most inexpensive educational agencies even in normal times and many of the older good books are likely to be sold at abnormally low prices for some time.

Notwithstanding these present special interests in the history of science, teachers should have a deeper interest in the permanent features of this history. Prominent among these features is the element of imperfection. Who is not interested when he first learns that Paciuolo the author of a very influential Italian work printed towards the end of the fifteenth century, tried to harmonize the facts that in Genesis the term "multiply" is used in the sense of increasing while if we multiply a proper fraction by a proper fraction we get a smaller product than either factor? Paciuolo concluded that increasing meant getting further away from unity; *e. g.*, $\frac{1}{2} \cdot \frac{1}{3} = \frac{1}{6}$, and $\frac{1}{6}$ is further from unity than either $\frac{1}{2}$ or $\frac{1}{3}$. In this way he thought he had explained the term multiply as regards proper fractions so as to be in accord with its use in the Bible.

Not an insignificant element of the educational value of the history of science is the opportunity which this history affords to inspire the student by the knowledge of having a clearer understanding of some scientific facts that the intellectual giants of earlier times had. If he is inclined to regard the rigorous geometrical demonstration of Euclid as superhuman he may be led to view the matter in a truer light by noting that Euclid was ignorant of the use of zero as a number as well as of the advantages of negative numbers. If he is dazzled by the deep mathematical insight of Newton he may realize his own mathematical advantages better when he learns that Newton knew nothing of the

brevity and elegance resulting from the use of determinants.

Fortunately the desire to excel is common to the young and old. I have often wondered to what extent the deep interest which women exhibit towards children, especially towards babies, is enhanced by the fact that in them they find human beings who do not pretend to know as much or more than they themselves do. At any rate the interest of young students can often be most easily aroused by guiding them so that they can experience that in at least some particulars they can make improvements on the work of others. The occasional discussion of possible improvements on the text-book or on articles in standard works of reference may serve a useful purpose if it is conducted in the right spirit. That some of the best works afford opportunities for such discussions may be illustrated by the article on "mathematical signs and symbols" in the new edition of the Encyclopedia Americana which is now almost completed and is noteworthy on account of its valuable mathematical articles.

The history of science is also useful because it instils optimism. That the history of science is in the main a history of progress needs scarcely to be emphasized in these days of rapid economic charges due to new scientific discoveries. The progress of science is in part reflected in the many new inventions and improvements contributing to our comfort in sickness and in health. The fact that these inventions and improvements are finally based on the work of such a large number of scientific investigators directs attention to the vast opportunities of rendering useful service in the field of science, and one of the most striking elements of the history of science is the fact that our rich scientific heritage is due to the work of millions for world betterment.

In the study of the history of science as well as in the study of science itself many students meet with the dilemma that what they would most like to know they can not know and what they can know they care little about. In both cases real progress is usually coupled with a willingness to work where progress seems possible. One of the most striking instances of this fact is furnished by the history of our common numerals. For centuries mathematical historians have been interested in the origin of these numerals and for a long time there was almost complete agreement that they were of Hindu origin and were transmitted to Europe by the Arabians. Hence the common name Hindo-Arabic numerals.

During the last dozen years various mathematical historians have re-investigated this question and have reached the conclusion that these numerals originated in Europe and not in Asia. One of the most active supporters of this new theory is G. R. Kaye, an Englishman residing in India, who wrote a book on "Indian Mathematics" (1915), and is inclined to give little credit to the Hindus for originality in mathematics. Instead of calling our common numerals "Hindu-Arabic" or "Babylonic-Hindu" it would be more in accord with our present state of knowledge to admit that they are of unknown origin, and if a student of the history of mathematics insists on knowing the origin of zero before taking up other historical questions it is likely that his knowledge of this history will remain zero.

As Cajori's history, to which we referred above, will probably be used widely as a text-book it seems desirable to refer here to a peculiarity which might otherwise cause perplexity. The author of this history speaks at various places about the origin of our common numerals and at all of these places save one he supports the theory that they are of Hindu origin. This single exception appears in a note on page 98 where he acknowledges our ignorance in regard to the origin of these numerals without, however, acknowledging explicitly his recent conversion to this view. It therefore happens that both those who support the theory of the Hindu origin of our common numerals and those who acknowledge agnosticism as regards their origin can find support of their views in different parts of the same book.

This singular fact seems to deserve public notice also because Cajori's work is the

largest and most modern general history of mathematics in our language and all English-speaking people who seek reliable information in regard to the development of this subject will naturally turn to it. The general reader will find here not only a history of the older mathematical developments but also a large amount of information about modern developments with due references to the contributions made by Americans.

Until recently America's share in the history of the advancement of mathematics was practically confined to the last fifty years, but recent study of the hieroglyphic writings of the Maya Indians of Central America and southern Mexico has established the fact that America has also a place in the history of ancient mathematics. In fact, the Maya used a kind of zero very early, possibly as early as the beginning of the Christian era. Their contributions are, however, very insignificant in comparison with those of the ancient Greeks, so that America has had only a small share in the advancement of mathematics except during the last half century.

Perhaps the most important feature of the history of science for teachers is the fact that in a broad way the history of the world portrays the history of the individual. Concepts which the world learned slowly are usually grasped slowly by the individual and the difficulties which the world experienced in the assimilation of these concepts are reflected in the individual student. Since the history of mathematics is so very old it is especially rich in suggestions as regards the learning process.

Another important feature of this history is that it tends to a clearer grasp of the most fundamental and fruitful facts of science. For instance, a great part of the development of mathematics during the nineteenth century centers in the ordinary complex numbers and in Taylor's expansion. It is interesting to note that for over fifty years from the time of the discovery of this expansion (1712) its importance was not generally recognized, and this fact furnishes another illustration of the difficulty involved in estimating the value of contemporary work in pure mathematics.

The history of science is interesting on account of its inexhaustible riches. Substantial progress in this field depends on the use of the intellectual telescope. Nothwithstanding the great importance of the use of the intellectual microscope which characterizes and ought to characterize most of our scientific work there is a charm for the student at times in using also an intellectual telescope in his scientific outlook. Like the distant sun warms and fructifies our earth so distant scientific facts stream into our present life and constitute the source of our present scientific activity. Just as we are interested in the sources of the rays of physical light that cheer us by day and by night so we should be interested in the sources of the rays of intellectual light shining through the scientific literature and illuminating our intellectual pathway.

Few may be interested in a proof of the fact that the point of inflexion of every curve whose equation is of the form

$$y = x^3 + ax^2 + bx + c$$

is a point of symmetry and hence the graph of a quadratic in one unknown has always line symmetry while that of a cubic has always point symmetry, but every one is likely to take an interest in the discussions of the ancient Greeks relating to whether a straight line can be equal to a curved one, as well as in the contention that Achilles could not overtake the tortoise since he must first reach the place from which the tortoise started, but by the time he reaches this place the tortoise has moved ahead. Such scientific ideas from the springtime of intellectual world life have a perennial interest, especially for those in the springtime of their own intellectual life.

The history of science best suited for the young student is that which relates to fundamental questions which are apt to perplex him and not that relating to the preservation of the obsolete from oblivion. The historic setting should constitute the sugar coating of the otherwise bitter scientific pills. The body of the pill should, however, be selected for its curative properties. It must be remembered

that many of us are intellectually sick because we have not properly assimilated fundamental truths and the function of the teacher is to cure such intellectual disease after a proper diagnosis as well as to provide wholesome food for the healthy mind. My advice to the Missouri teachers therefore is: Provide yourself with a considerable variety of pills sugar-coated with scientific history and use them somewhat sparingly like other medicine, but be prepared to use them both as a preventative and as a cure whenever the occasion presents itself.

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THE SINGING SANDS OF LAKE MICHIGAN

The dune region of Lake Michigan extends along its eastern shore from Gary at the southern extremity to Mackinac at the northern with comparatively few breaks or interruptions. Throughout this region the sands near the water's edge, in dry weather, emit a peculiar but definite and unmistakable sound when the foot of the pedestrain pushes through them in an abrasive way. This unusual sound from an unusual origin is a source of great delight to children and an inciter of the curiosity of their elders, who, however, rarely pursue the subject far enough to arrive at an explanation for it. The sound is produced not only by the leather-shod foot, but is emitted also if the bare foot or hand is struck through the grains or if a stick is trailed, boy-fashion, behind.[1]

The sound has been compared or the attempt has been made to relate it to that produced by the pedestrian walking through soft snow; to the crunching noise so frequently noticed when walking through snow after very cold weather or by the wheel of a vehicle on such snow; also to the sound emitted by hard, granular snow when one walks through it; but it is like none of these and has a distinctive character all its own.

In a preliminary way several observations should be recorded as to the bearing of location and conditions of various sorts on the singing sands. The sound is produced only when the sand is dry, and apparently the dryer the sand is, the louder the sound produced. In wet weather or when the sand is moderately moist, the sound is not produced. In summer and indeed in the hottest weather the sound seems to be loudest, other conditions being the same, but it can be clearly heard at all seasons of the year, including winter, whenever the sand is dry. As one walks away from the water's edge he may be astonished to find out that the sound-producing sand ceases rather abruptly about fifty to one hundred feet from the shore line. These limits may vary at different locations but on the whole they are substantially correct. Back and away from the shore line, in blowouts and on the sides and tops of the dunes, the sound is never produced. There is no observable difference between the sand located near the shore and that located farther back or that forming the dunes, and indeed the sand which is washed up by the waves is that which, blown by the wind, goes to form the dunes.

The upper beach limit of the singing sands

1 (See Thoreau's "Journal," entry of September 22, 1858, in "Autumn.") "One mile southeast of the village of Manchester struck the beach of 'musical sand,' . . . . We found the same kind of sand on a similar but shorter beach on the east side of Eagle Head. We first perceived the sound when we scratched with an umbrella or the finger swiftly and forcibly through the sand; also still louder when we struck forcibly with our heels, 'scuffling' along. The wet or damp sand yielded no peculiar sound, nor did that which lay loose and deep next the bank, but only the more compact and dry. The sound was not at all musical, nor was it loud. . . . R——, *who had not heard it*, was about right when he said it was like that made by rubbing wet glass with your finger. I thought it as much like the sound made in waxing a table as anything. It was a squeaking sound, as of one particle rubbing on another. I should say it was merely the result of the friction of peculiarly formed and constituted particles. The surf was high and made a great noise, yet I could hear the sound made by my companion's heels two or three rods distant, and if it had been still, probably could have heard it five or six rods."